

EMISSIONS REDUCTION CHALLENGES

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Heavy duty diesel engines utilized in on-highway applications have been emissions-regulated for twentyfive years. In the year 2004, a dramatic reduction of 50% NOx over 1998 levels will be further required. This poses significant technological challenges, while still meeting the needs of the trucking industry.

Traditional technical approaches used thus far, through the regulations applicable in 1998, will not suffice. Exhaust Gas Recirculation (EGR) appears to be the critical technology needed to effectively reduce NOx to the desired 2.0 g/hp.hr transient cycle emissions target. The reduction of NOx is expected to increase Particulates, requiring additional control technologies, including much reduced lubrication oil-contribution to Particulates, to meet the 0.10 standard. The engines will need to be emissions-certified for upto 435,000 miles, as opposed to the current 290,000 miles.

EGR poses significant challenges in this application, with either the low-pressure (post-turbine to pre-compressor) or the high-pressure loop (pre-turbine to post-compressor) . Effective NOx reduction requires EGR applied at high engine operating loads, where almost 40% of the total NOx is formed. Because

exhaust pressure is typically lower than boost pressure, EGR flow must be forced, possibly by a back pressure valve. Engine performance can suffer, and to maintain the air/fuel ratio for fuel economy and Particulates control, a Variable Geometry Turbocharger may need to be applied. The EGR will require cooling, either through a Jacket Water Cooler or the ATAAC.

Besides the potential cost increases to the engine, several issues arise due to EGR. Soot-in-oil can cause elevated wear rates, and turbocharger fouling and wear. EGR Cooler efficiencies can degrade, requiring additional maintenance. The Federal Transient Emissions Test will require much improved EGR control and regulation to maintain proper air/fuel ratios to limit soot.

A Caterpillar Medium Heavy Duty engine was evaluated for component wear due to EGR application, in a joint program with Ricardo. Thin Layer Activation (TLA) techniques were utilized through short-duration runs at various engine operating conditions. Radioactivity level changes in oil samples were an indicator of component wear. The results provided some indication that EGR may be used in today's

highly rated truck diesel engines without the onset of excessive soot loading and wear. However, a significant amount of endurance and field testing will be required before production.

There does not appear to be available any production viable in-cylinder NO_x control technology that can maintain the 2.0 g/hp.hr level. Development of effective in-cylinder catalytic reduction of NO_x and Particulates is being proposed for a future DOE program.

Fuel Injection Rate Shape and Control is another technology that may be utilized for both NO_x and Particulates containment. It is fully expected that all 2004 engines will need electronic injection systems, to control key parameters through the entire operating range of the engine, including varying ambient temperature, altitude and start-up conditions.

DeNO_x Aftertreatment systems have shown the potential for large reductions in NO_x and Particulates, but are generally not amenable to mobile application. However, they do provide the potential for the engine to be optimized for fuel economy, while the NO_x may be reduced by the Aftertreatment system. The development for a non-thermal Plasma Aftertreatment of NO_x is also being proposed for a future DOE program. Any losses in fuel economy due to the system energy needs may be more than compensated for by the gains from the engine now capable of being optimized for minimum fuel consumption.

For improved engines of the future, current diesel fuel will also need to be modified.

Besides the conventional arguments in favor of improving the cetane and reducing the aromatics and sulfur, it is conceivable that the restructuring of the Hydrogen-Carbon bonds themselves may improve combustion characteristics to reduce in-cylinder emissions. Partnering between Fuel and Engine companies, supported by the DOE, may help determine an improved compression ignition fuel of the future.

The technologies incorporated into heavy duty diesel engines to meet emissions regulations will ultimately have to meet the needs of the end-user, the trucking industry. Feedback from engine customers indicates that they would prefer engine manufacturers to consider transparent technologies i.e. the engine needs to look and work the same, but be cleaner for emissions regulations. Reliability and durability consistently remain on top of their list of requirements, and for improved productivity and reduced downtime, the technologies applied must promote increased service intervals. Fuel economy improvements are critical to help offset increasing labor and other costs, especially since most fleets operate with incomes that are 1-3% above their costs. Technologies that entail a penalty in fuel economy will not be acceptable in the marketplace.

To meet the needs of regulatory and customer requirements of 2004 and beyond, the heavy duty mobile application diesel engine will need significant technology enhancements. There appear to be major challenges ahead in selecting and developing those technologies that will still provide the trucking industry with the best owning and operating costs with the diesel, the power plant of choice.